



STUDY OF THE PARAMETERS AFFECTING OPERATOR DOSES IN INTERVENTIONAL RADIOLOGY USING MONTE CARLO SIMULATIONS

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INTRODUCTION

WHY USE MONTE CARLO SIMULATIONS?

During IR procedures many parameters influence operators' doses.

In clinical practice it is impossible to study each parameter separately, as many of them change simultaneously.

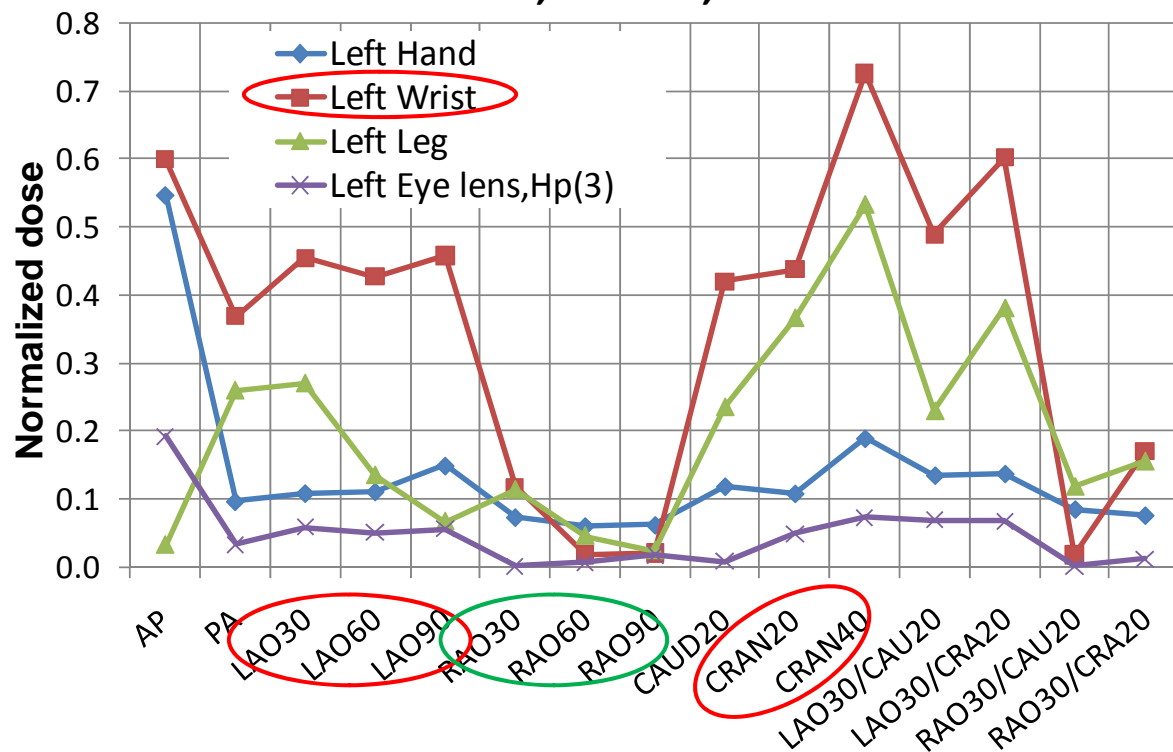
With MC simulations the influence of each parameter was studied in order to provide specific guidelines concerning the radiation protection of the staff involved in IR procedures.

STUDIED PARAMETERS

- Beam projections
- Protective equipment
- Beam quality
- Field size
- Access of the catheter – position of the operator

BEAM PROJECTIONS

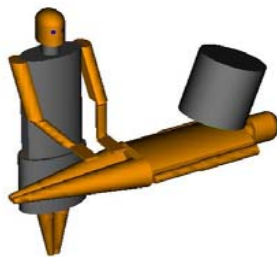
Head Irradiation, Radial access
80kV, 3mmAl, 0mmCu



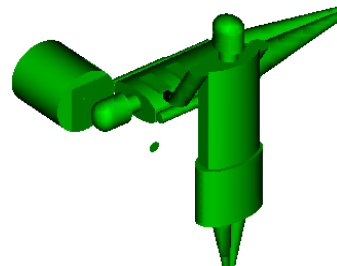
- LAO projections → higher doses than RAO.
- CRAN projections → high doses.
- Radial access (operator close to irradiating field) the left wrist is generally the most exposed for this geometry.



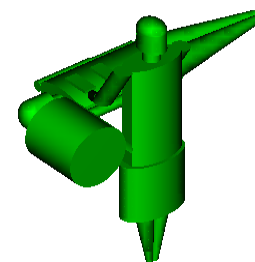
PA



CRAN



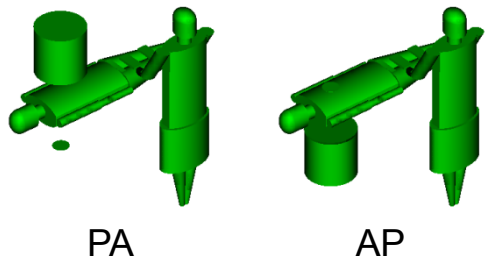
LAO90



RAO90

BEAM PROJECTIONS

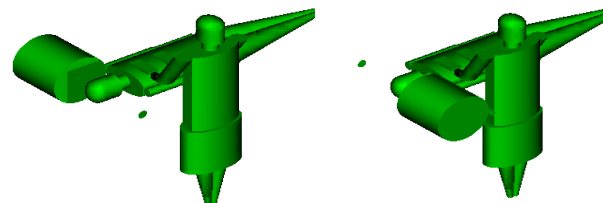
TUBE BELOW (PA)-ABOVE (AP)



PA

AP

LATERAL PROJECTIONS

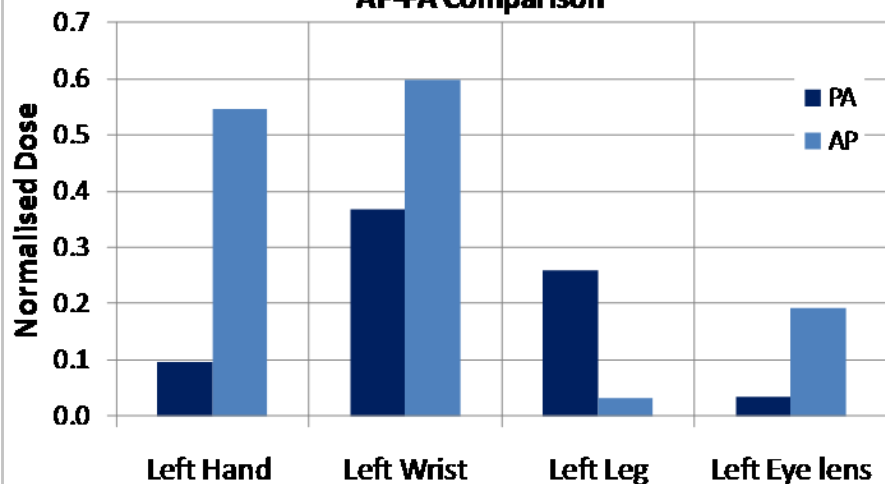


LAO90

RAO90

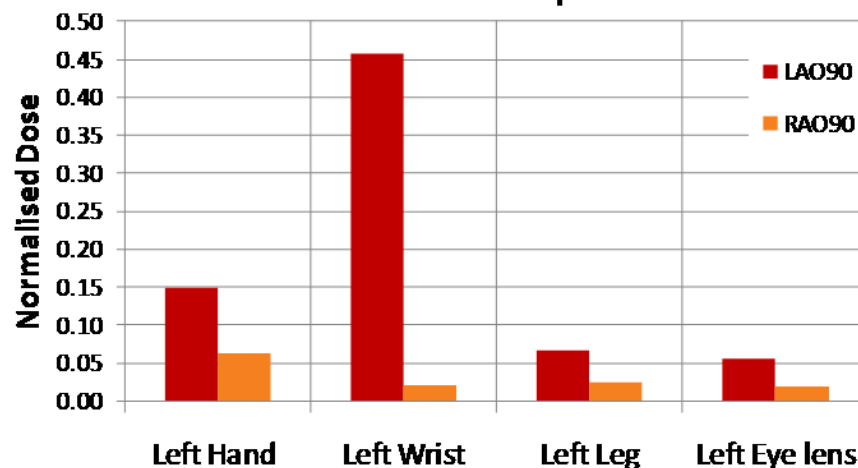
no shields
are present

Head Irradiation, Radial access
80kV, 3mmAl, 0mmCu
AP-PA Comparison



no shields
are present

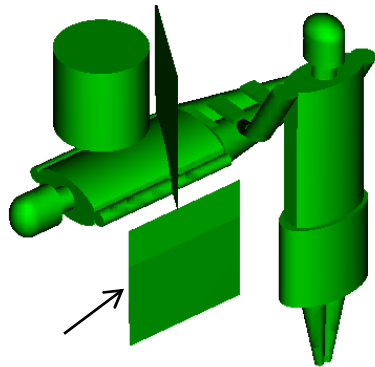
Head Irradiation, Radial access
80kV, 3mmAl, 0mmCu
LAO90-RAO90 Comparison



Head Irradiation	L hand	L wrist	L leg	L eye lens
Ratio (AP/PA)	5.6	1.6	0.1	5.8
Ratio (LAO90/RAO90)	2.4	22.1	2.7	3.1

PROTECTIVE EQUIPMENT

Ceiling shield A1:
shield close to the patient



Ceiling shield B1:
rectangular shield touching the patient

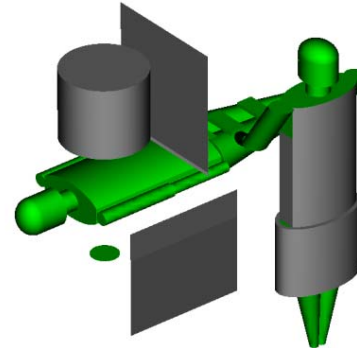
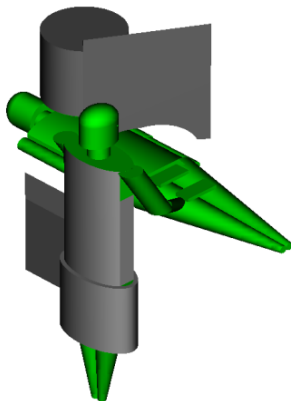
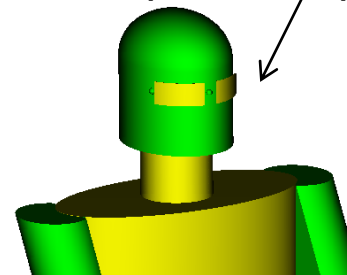


Table shield

Ceiling shield A2:
shield 15cm above the patient



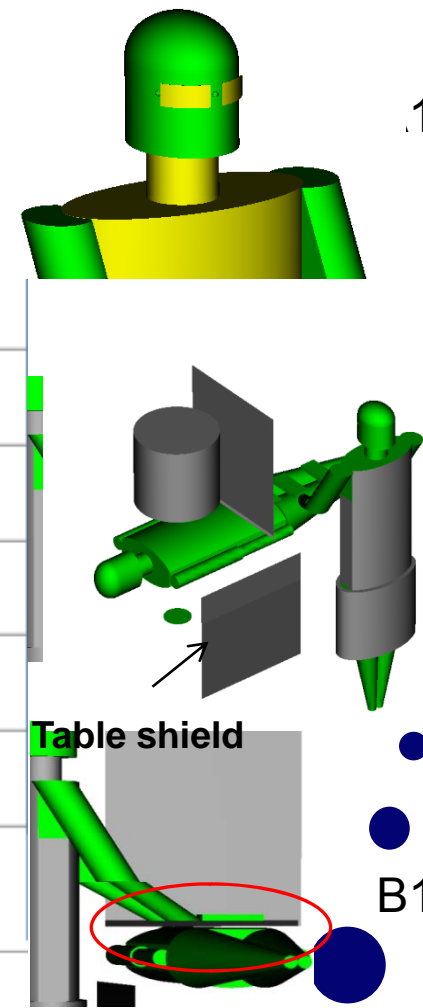
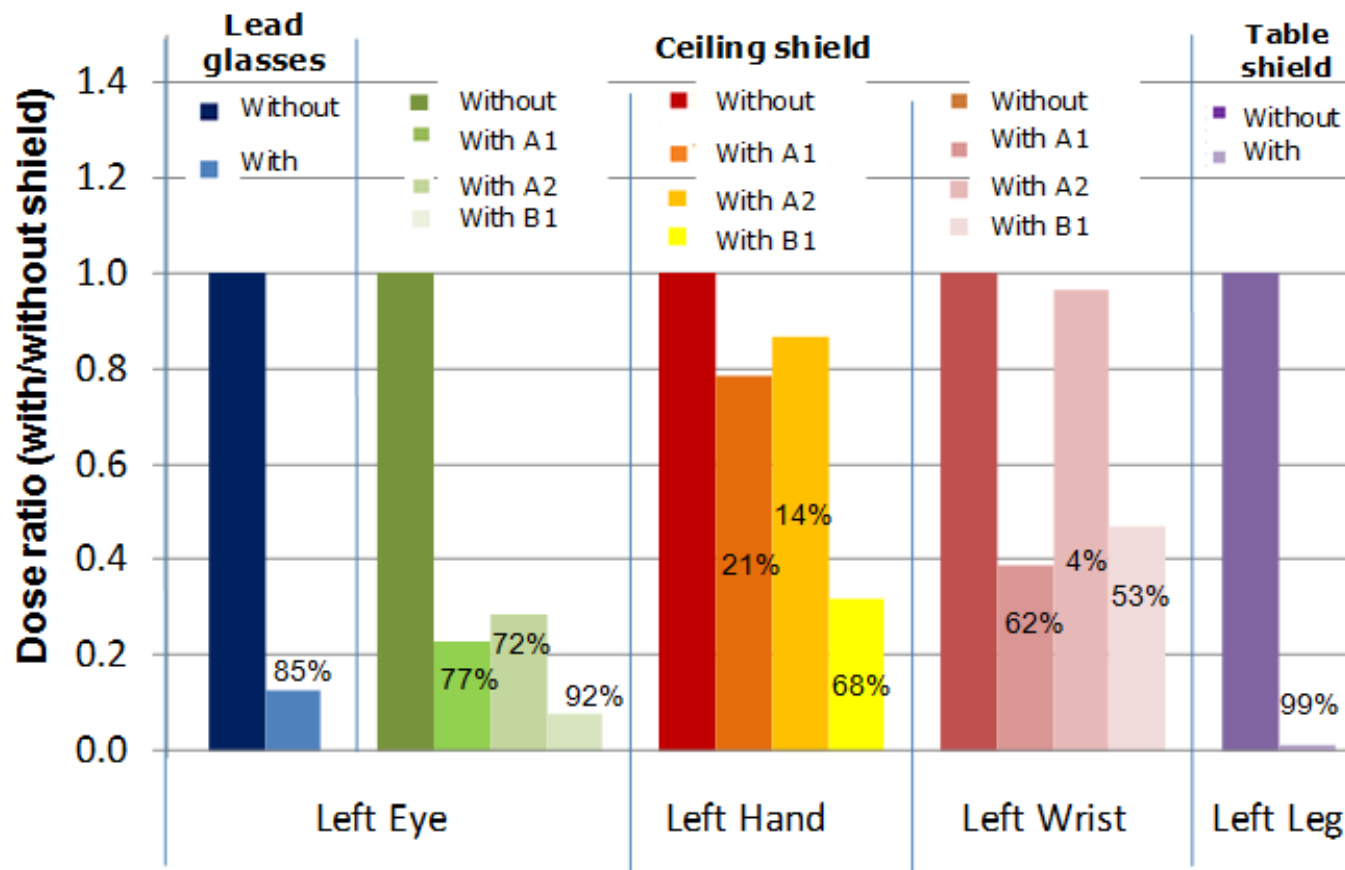
Lead glasses
(0.5 mm Pb)



PROTECTIVE EQUIPMENT

PA PROJECTION – THORAX IRRADIATION

Effect of ceiling shields for PA projection

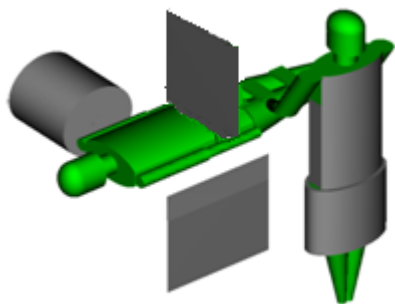
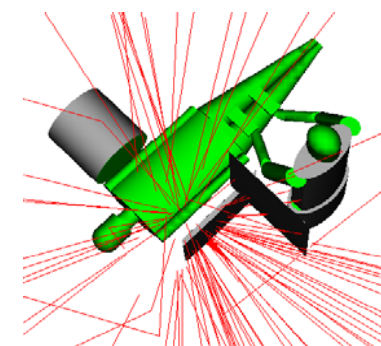
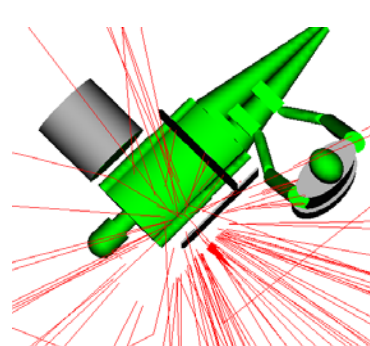


PROTECTIVE EQUIPMENT

LATERAL LAO 90° PROJECTION – THORAX IRRADIATION

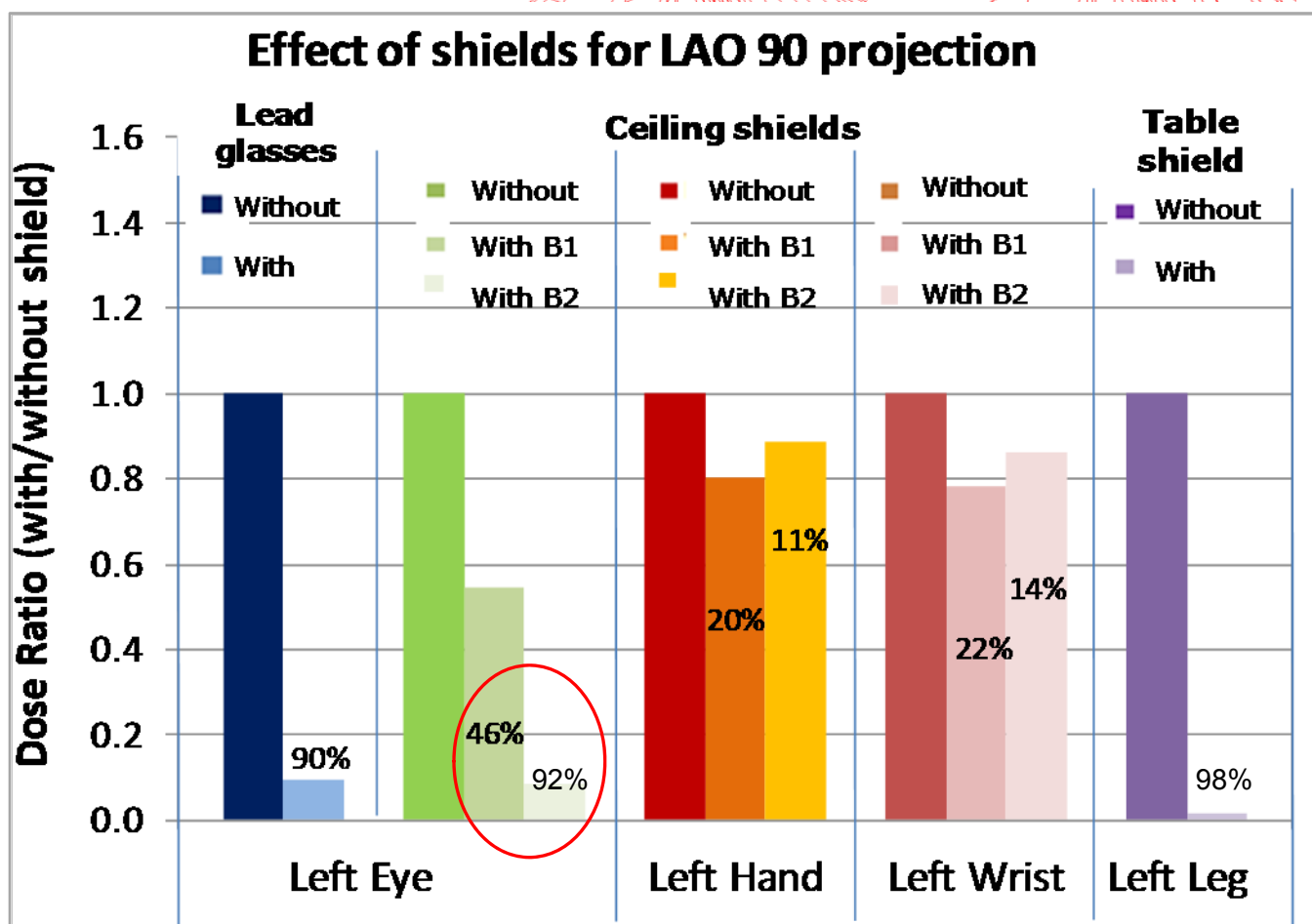
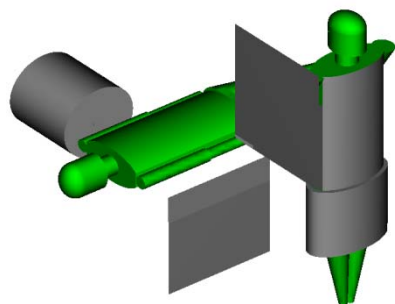
Ceiling shield B1 :

Slightly more effective to hands and wrists for LAO90 lateral projection

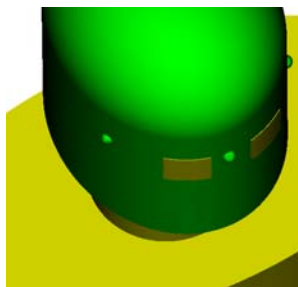


Ceiling shield B2 :

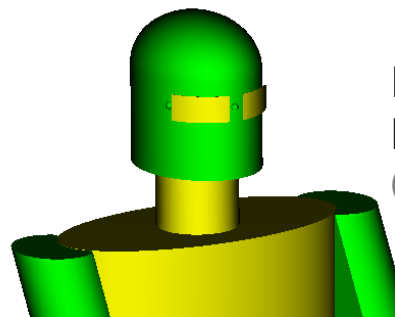
Much more effective to the eyes for LAO90 lateral projection



LEAD GLASSES



Small lenses



Large lenses
(x 2.5 larger)

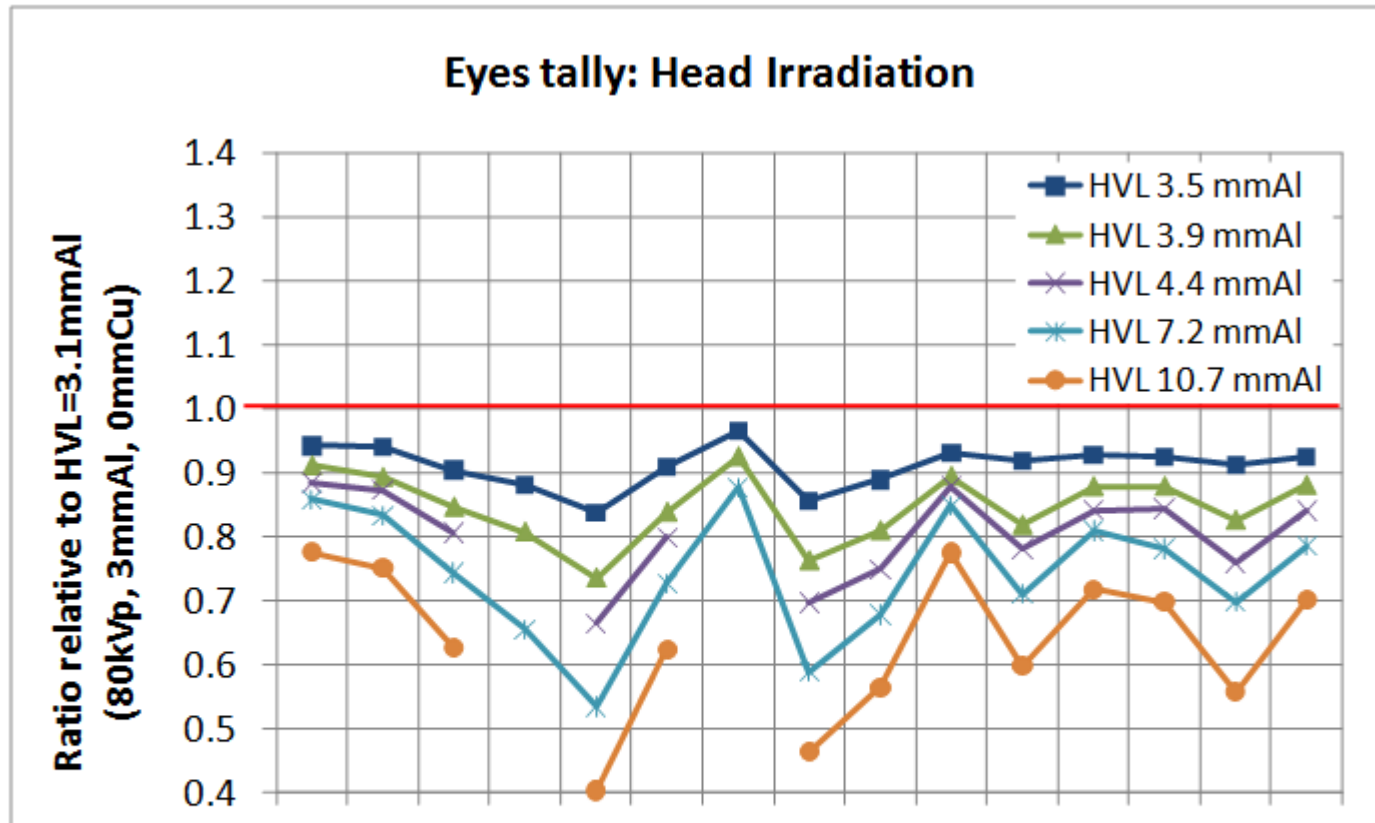
90 kVp, 3 mm Al, 0 mm Cu

Field size at image intensifier = 20 cm diameter

	Left eye Ratio with/without glasses	
	PA	CRA20
No lead glasses	1	1
Small lens (0.5 mm Pb)	0.30	0.28
Large lens (0.5 mm Pb)	0.15	0.14
Small and thick lens (1.0 mm Pb)	0.26	0.25
Large and thick lens	0.14	0.13

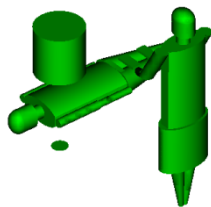
- Lens thickness >0.5 mm Pb does not improve the protection of the eye lens significantly
- Large lenses that cover better the eyes are preferred

BEAM QUALITY



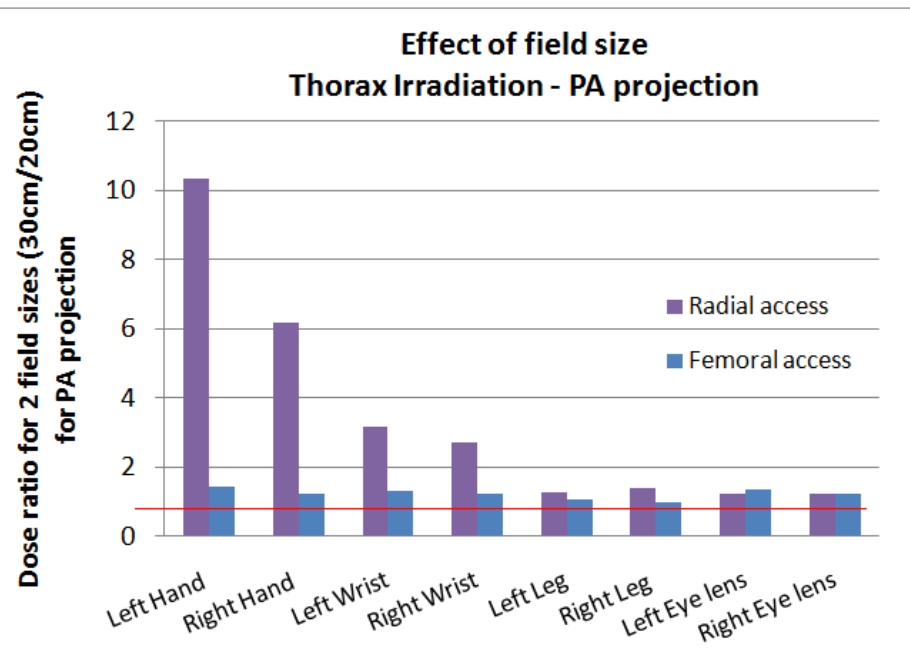
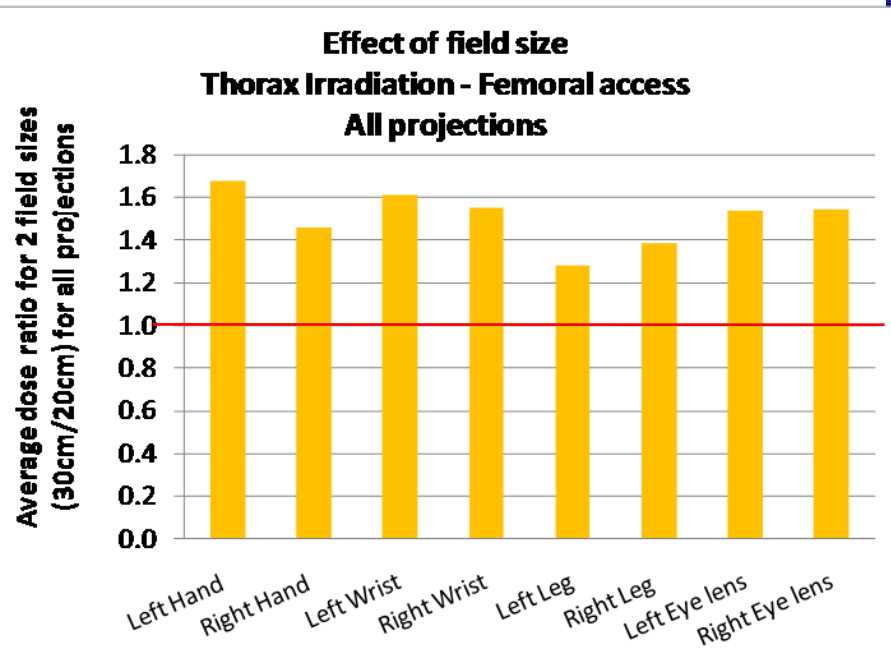
Doses can be reduced significantly (up to 60%) when harder beam (higher filtration) is used as long as image quality/contrast remains satisfactory

FIELD SIZE



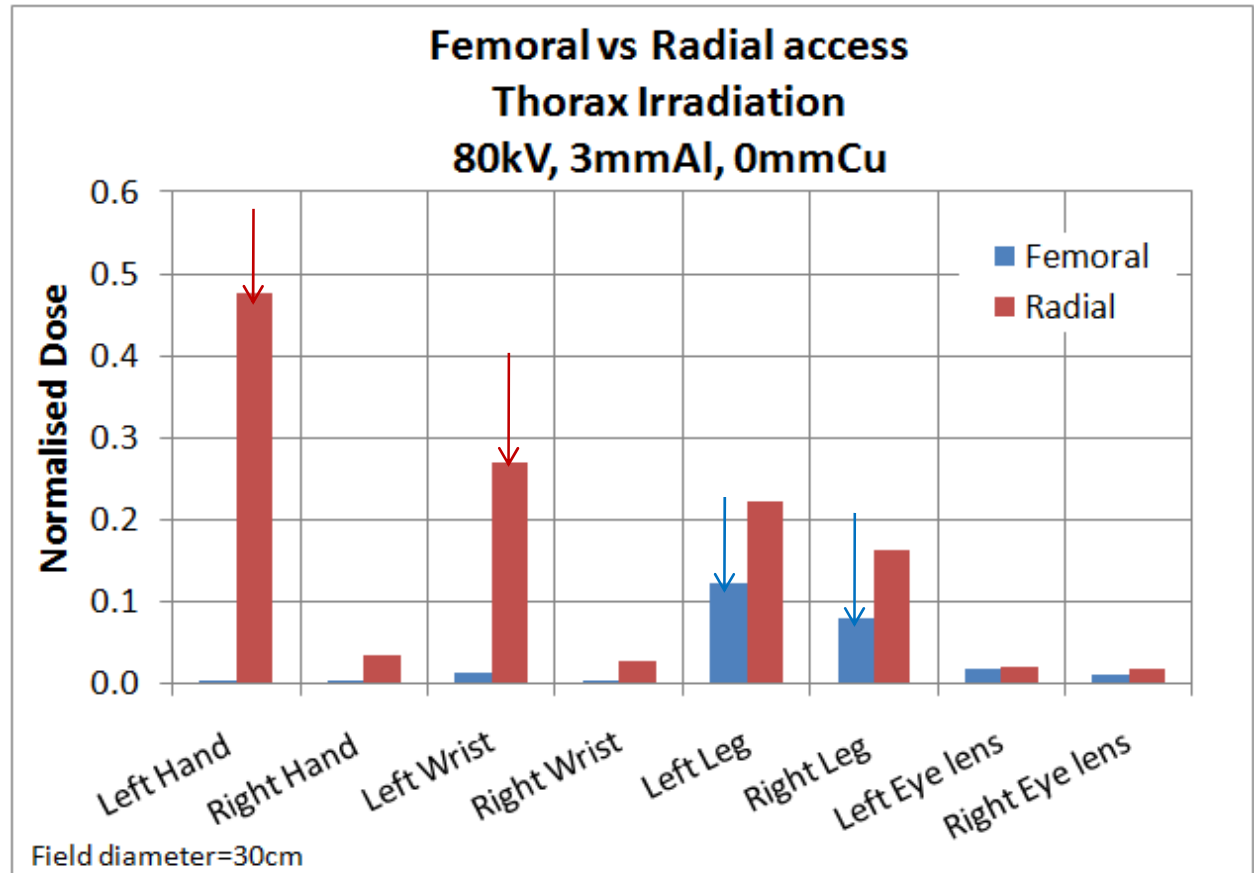
- For all monitored positions the doses are higher when a larger field size is used (1.3-1.7 times).
- The largest dose increase is observed to the left hand which is the closest to the irradiating field.
- The dose to the eye lenses is also influenced by the field size.
- The dose to the legs seems to be the less affected in this case.

The dose reduction to the hands and wrists because of a more collimated beam, becomes much more important (~10 times) when the operator stands closer to the irradiating field.



ACCESS OF THE CATHETER – POSITION OF THE OPERATOR

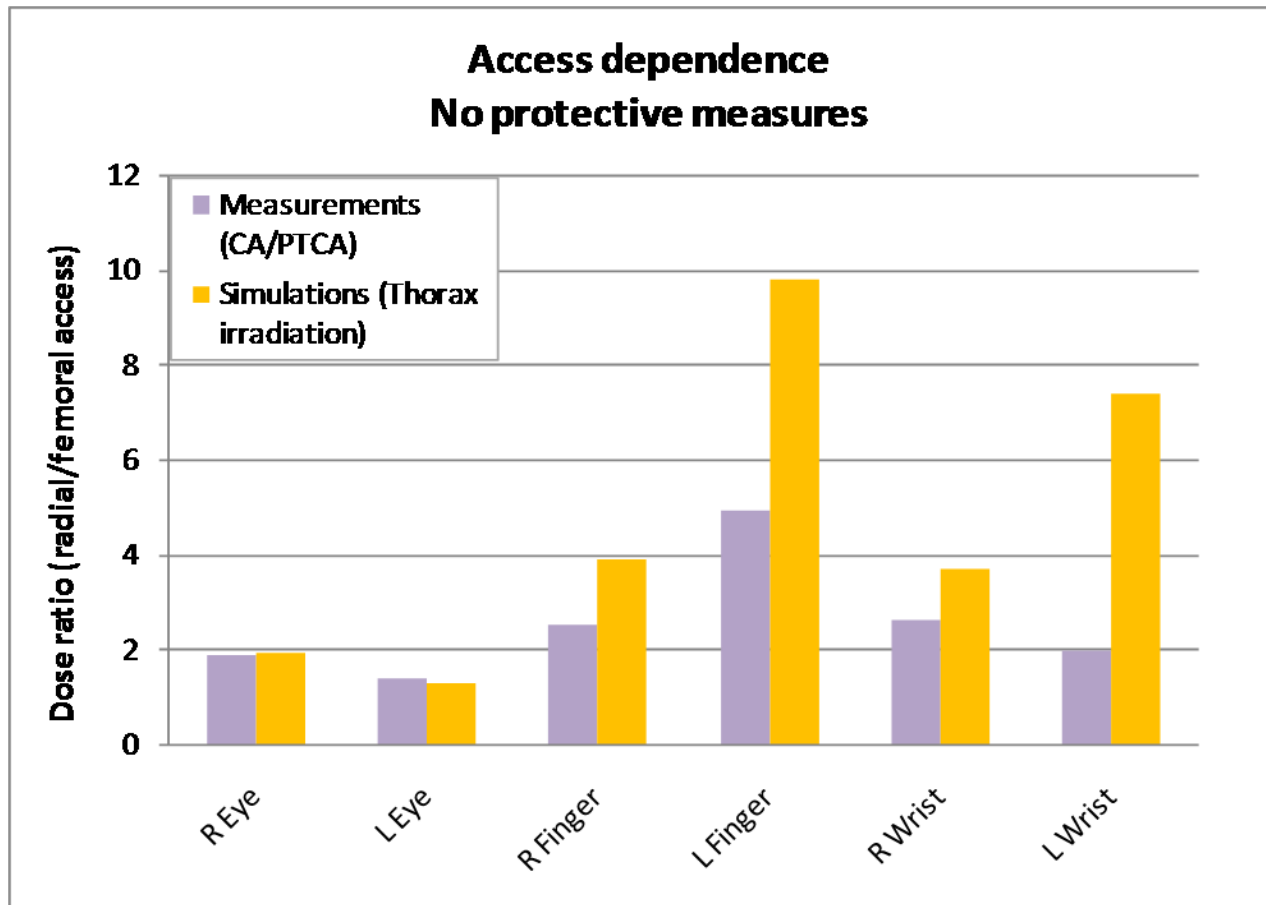
PA projection
No protective shields
Field diameter=30cm
Femoral → Radial = 40cm



The hands and wrists are the most affected when approaching the irradiation field.
The eyes are less affected because, even though the operator stands closer to the primary beam when using radial access, the image intensifier plays the role of shielding (depending on the projection).

MEASUREMENTS & SIMULATIONS COMPARISON

ACCESS OF THE CATHETER



The effect of the access position of the catheter to the doses (for under-couch irradiation):

- Is more important on the fingers and wrists in both cases.
- Less important for the eyes

The absolute values of the ratios cannot be compared as there are several differences between simulations and measurements (only 4 projections (PA, LAO 90°, RAO 30°, CRAN 40°), one beam quality - 70kVp, 3mmAl, 0mmCu (HVL=2.7mmAL), and one field size (20 cm diameter at the II) were examined for the simulations).

CONCLUSIONS

- Undercouch irradiation is advised. When the tube is above the operating table the hands and the eyes are more exposed (up to ~6 times for the eyes).
- LAO and Cranial projections (tube closer to the operator) deliver higher doses than RAO and Caudal projections respectively.
- The ceiling suspended shield is very effective for protecting the eyes and should be used especially when lead glasses are not worn and/or over-couch irradiation is used.
- Ceiling suspended shield with lead stripes at the bottom, to eliminate the gap from the patient, is advised (can increase the protection of the hands of ~45%).
- Table shield is very effective for the protection of the legs especially for under-couch irradiations (up to 99%).
- Additional shield for lateral projections should be considered for the protection of the eyes.
- Lead glasses with large lens area are preferred. Equivalent thickness of more than 0.5mm Pb is not advised.



CONCLUSIONS

- Harder beams deliver lower doses to the operator (up to 60%).
- Beam collimation is an effective way to reduce the exposure especially to the hands and wrists. The dose reduction is much more important when the operator's hands are close to the irradiating field (~10 times).
- Hands and wrists are the most affected when approaching the irradiation field.
- The most exposed areas for radial access are the hands and for femoral access are the legs, when no protective shields are used.

